inductive coupling using large electromagnetic coils to induce an electrical field at the nonunion site.

There are disadvantages to these techniques: healing may take up to six months in large bones and patients may not bear weight for at least the first three months of treatment. All procedures but the noninvasive coil electrodes have a risk of infection.

A new type of noninvasive electrical stimulation using capacitive coupling is in its final stages of patient testing. In capacitive coupling, an electrical field is induced in bone by small stainless steel electrodes placed on a patient's skin at the nonunion site. The device is powered by a 9-V battery attached to the outside of the cast allowing the patient to move about freely. This is an office procedure, and the patient may bear weight as tolerated during the course of treatment.

These electrical stimulation techniques are reported to be successful in 70% to 80% of cases, but the rate varies with the location of the nonunion. Nonunion of the tibia responds to electrical stimulation—more than 90% of patients heal completely, whereas nonunion of the humerus responds very poorly. Humeral nonunions frequently develop a synovial pseudarthrosis (false joint) consisting of a fluid-filled sac between the fracture fragments. This allows gross motion at the nonunion site and should be treated by surgical removal of the synovial sac, rigid fixation and bone grafting. If this treatment fails, electrical stimulation may be successful once the nonunion has been well stabilized.

At the present time there is no clear evidence that electrical stimulation is effective in treating fresh fractures, nor that adding this treatment to conventional bone grafting will significantly increase the chance of healing.

Bone grafting and rigid fixation by either external or internal devices are still acceptable techniques and have an equal or slightly higher success rate when compared with electrical stimulation. However, all require a surgical procedure with the accompanying risk of infection.

Electrical stimulation is a safe and effective addition to the procedures available to orthopedic surgeons for the treatment of unhealed fractures.

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Management of Major Pelvic Ring Fractures

FRACTURES OF THE PELVIS can be divided into minor and major ones. The minor fractures include avulsions and those that ostensibly only disrupt the pelvic ring at one point. Major fractures involve the pelvic ring at two or more diametric positions and may be stable or unstable. Most fractures caused by shearing forces, some caused by anteroposterior compression and occasionally those caused by lateral compression are unstable.

Instability is suggested by a patient's history, physical examination and by the results of special radiologic examinations. Anteroposterior and 45-degree inlet and outlet radiographs of the pelvis are essential. Cephalad migration of one hemipelvis, fracture of the fifth lumbar transverse process and avulsion fractures of the ischium and ischial spine all suggest instability. The possible points of pelvic ring disruption include the sacrum, sacroiliac joint, ilium, acetabulum, pubic arches and symphysis pubis. Computed tomography is often helpful in confirming the clinical and plane radiographic impression and assists in planning therapy.

The time-honored treatment of pelvic fractures with slings and traction is now rarely indicated and may in fact be detrimental in unstable fractures caused by lateral compressive forces. The pelvic sling is usually uncomfortable, makes nursing difficult, prolongs hospital stay and often will not achieve a good reduction or stabilization.

Recent advances in external and internal fixation techniques have greatly improved the capability to deal with the unstable pelvic fracture. A simple tie-beam arrangement with two Schanz type pins in each anterior iliac crest region connected by rods stabilizes anterior disruptions when the posterior sacroiliac interosseous ligaments are intact. More massive external fixators with pins above and below the anterior superior iliac spine may be used for the Malgaigne type fracture. However, the emphasis has recently been placed more on internal fixation with screws, rods or plates posteriorly combined with double plating of the symphysis pubis or a simpler frame anteriorly.

The advantages of external fixators and internal fixation techniques include better stabilization, improved control of pain and bleeding, easier nursing and shorter hospital stay.

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External Fixation of Tibia Fractures

MANAGEMENT of a severe open tibia fracture with extensive soft tissue injury continues to pose a therapeutic dilemma for most orthopedic surgeons. Although external fixation has been practiced for centuries, the renewed interest in this treatment has led many orthopedists to review and modify their fracture management protocols. The classic "pins and plaster" technique is a modification of the external fixation system. The lack of accessibility to the wound, unstable pin fixation, inability to reset the fracture if necessary and bulky casts have led trauma surgeons to search for a more rigid, low profile, external fixation system.

Although there are many variations on a theme, external fixation frames are basically designed for one-plane or two-plane fixation, depending on the stability of the fracture. Less rigid frames consisting of one-plane or half-pin anterolateral frames are indicated in the open type II or III tibia fracture with minimal comminution and minimal soft tissue involvement. On the other hand, two-plane frame fixation, as shown by the quadrilateral or the Delta frame, is indicated for severe open fractures of the tibia where there is segmental bone loss, severe comminution or massive soft tissue injury. The key difference is that one-plane frame fixation provides less stability than the two-plane or Delta frame fixation configuration.

Tibia external fixation is technically facilitated by the use of C-arm fluoroscopy and a radiolucent table extender. This technique preserves precious intraoperative time that is otherwise lost awaiting development of the roentgenograms. Occasionally stability is enhanced by one or two strategically placed intrafragmentary compression screws that provide temporary rotational control, length and reduction while the external frame is being constructed. After the operation, dorsiflexion foot splints should be applied to prevent equinus deformities. Fastidious care of the pin should be instituted and the leg should be elevated to prevent edema during the early phases of treating the wound.

Prolonged immobilization of patients has been implicated in nonunions of the tibia treated with external fixation. A recent review of tibia fractures treated at the University of California, Davis, Medical Center in Sacramento suggests that a brief period of external fixation—six to eight weeks—followed by early bone grafting and the use of weight-bearing casts has resulted in high rates of union and few pin tract complications. This temporal relationship provides maximum soft tissue benefit and does not jeopardize bone union.

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Management of Long Bone Fractures With External Fixators

IN RECENT YEARS external fixation has become the treatment of choice in the management of type III fractures of long bones. The advantages of rigid external fixation in these injuries is that it allows for complete visualization of the soft tissues, ease of inspection and accessibility and allows for repeated debridements without removal of cumbersome dressing and plaster casts.

In addition to the tibia, we have found external fixation useful in the management of fractures of the femur that involve considerable soft tissue and bony injury, when intermedullary fixation is not appropriate or not possible. External fixation allows the patient to return easily to the operating room for wound debridement and delays primary closure or skin-grafting or both until the appropriate time.

External fixation can be used in type III injuries of the humerus and forearm when there is extreme soft tissue destruction and bony loss. Many of these injuries are associated with close-range bullet wounds, which cause extensive comminution of the long bones. External fixation allows us to maintain bony alignment and length and adequately debride soft tissue areas preparatory to reconstruction of both the bony and soft tissue envelopes. Our goals in these injuries include closure of the wounds with appropriate rotational flaps or grafts or both within the first eight days.

With external fixation in place and frames designed to manage the type of stability needed, we can maintain bony alignment and soft tissue length until wounds are well healed and decide later if we wish to return to the injured area for definitive bone-grafting. Many of these patients have more than one injury and external fixation allows the patient to get out of bed soon, which can improve pulmonary and cardiovascular management and decrease complications in these areas.

If microvascular techniques or local coverage is not possible, external fixation can maintain leg position in cross-leg pedicle flaps—a good alternative to using large plaster casts. Patients are more comfortable and the complete flap can be seen because there are no casts or occlusive dressings in the way.

External fixation is of benefit in extremely unstable comminuted closed fractures and rigidity of the frames can be modified to allow for alignment, but also allow for transmission of forces across the fracture site to stimulate callus formation. Unfortunately, the exact degree of rigidity for ideal periosteal new bone formation is not known and awaits further research.

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